

ELASTIC AND INELASTIC PROTON SCATTERING

MEASUREMENTS OF S AND P-A USING THE $^{12}\text{C}(p,p'\gamma)$ REACTION AT 150 MEV

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We have recently begun a study of the spin excitation mechanism in the scattering of intermediate energy protons. The objectives of our initial measurements are a determination of the spin flip probability (S) and the difference between the polarization and analyzing power (P-A) for scattered protons exciting the 15.11 MeV (1^+ , $T=1$) state in ^{12}C . These measurements were made using the $^{12}\text{C}(p,p'\gamma)$ reaction at a bombarding energy of 150 MeV. This is the first reported use of the gamma-ray coincidence technique to determine S and P-A at intermediate energies.

The 1^+ state at 15 MeV in carbon is a good choice for a first measurement of this kind primarily because the strong gamma-ray branching ratio to the ground state ($\Gamma_{\gamma_0}/\Gamma = .88$) allows an extraction of S and P-A with high accuracy. There also exist for this state high- q electron scattering results¹ at 180° and cross sections and analyzing powers for intermediate energy proton scattering² which have motivated previous theoretical treatments. Some polarization transfer measurements have also been made,³ although primarily at lower values of momentum transfer.

Microscopic calculations within the DWBA have shown the spin flip probability to be most sensitive to the spin-dependent central and tensor components of the effective nucleon-nucleon interaction at this energy. In the present experiment, S has been measured for four

values of q from 200 to 400 MeV/c, where these calculations show the tensor interaction to dominate. In addition to providing a sensitive test of this component of the nucleon-nucleon force, accurate measurements of S in this high- q range may also provide a means for observing possible precursor effects toward a pion condensate in nuclei.

The difference between the polarization and analyzing power for inelastic scattering has been little studied.⁴ It results from an orthogonal combination of spin flip amplitudes ($P-A \sim \sigma^{+-} - \sigma^{+}$, whereas $S \sim \sigma^{+-} + \sigma^{+}$, where $\sigma(\theta) \sim (\sigma^{++} + \sigma^{+-} + \sigma^{+} + \sigma^{--})$, and is determined with the $(p,p'\gamma)$ reaction by a comparison of measured spin flip probabilities when the incident beam polarization is reversed.⁵ Previous measurements of P-A for elastic scattering are of considerable interest because they directly determine time reversal noninvariant scattering amplitudes. Considerable experimental and theoretical work remains to be done to provide a similar level of understanding of the significance of P-A for inelastic scattering.

In the present measurements the QDDM spectrograph was used with a helical-wire position detector followed by two $(\Delta E, E)$ scintillators in the standard configuration. De-excitation gamma-rays were observed at 90° to the reaction plane with a 10" diameter \times 12" long NaI(Tl) crystal suspended directly above the

scattering chamber. A cast lead shield surrounded the detector, which was further encased in a borated polyethylene shield. Event time-of-flight with respect to the pulse-selected beam was used to lower the fast neutron background. The effects of the high background rates were further reduced with pile-up rejection and gain stabilization circuitry similar to those used for previous radiative capture studies with this detector.⁶

All data were recorded in event mode and sorted on-line into histograms corresponding to coincident and singles events. Figure 1 shows two of these spectra at $q=200$ MeV/c for one spin orientation of the incident beam. For these data, in which final sorting cuts have

not yet been applied, the true-to-accidental coincidence ratio is approximately 10 to 1. Because the gamma-ray detector remains fixed as q is varied, and therefore the probability for accidental coincidences remains fixed, the resultant T:A ratio at any other value of q is determined only by the ratio of peak to background in the singles spectrum. This fact enables highly reliable extraction of coincidence yields out to large values of momentum transfer using the $(p,p'\gamma)$ reaction. Data for this first run are currently being analyzed, and will be presented at a later time.

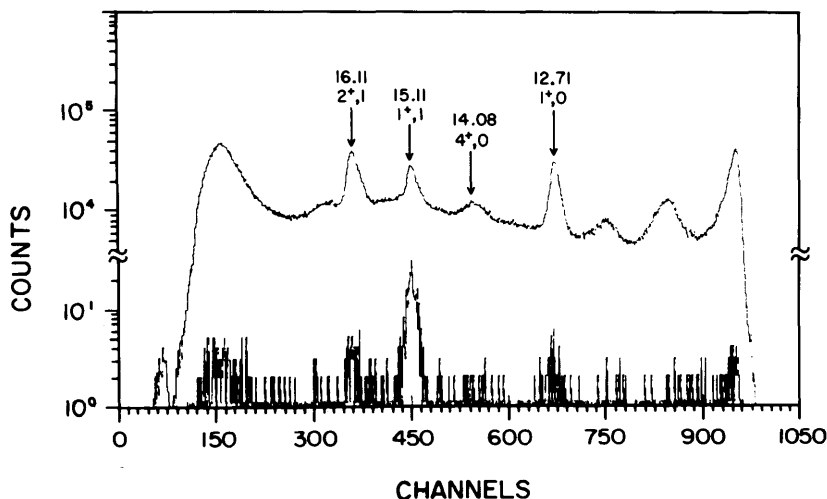


Figure 1. On-line spectra of inelastically scattered protons taken at $\theta_{lab}=22^\circ$ with a 150 MeV polarized (spin up) beam. The upper curve is a singles spectrum, the bottom shows protons in coincidence with any gamma ray in the out-of-plane NaI counter.

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